Design of Ergonomic Knife Handle

Thesis submitted in partial fulfilment of the requirements for the Degree of

Bachelor of Technology (B. Tech.)

in

Industrial Design

by

Ayushi Khetan (111ID0469)

NATIONAL INSTITUTE OF TECHNOLOGY ROURKELA
769008, INDIA (2011-2015)

Declaration

I hereby declare that this thesis is my own work and effort. Throughout this documentation wherever contributions of others are involved, every endeavour was made to acknowledge this clearly with due reference to literature. This work is being submitted for meeting the partial fulfilment for the degree of Bachelor of Technology in Industrial Design at **National Institute of Technology, Rourkela** for the academic session **2011 – 2015.**

Ayushi Khetan

(111ID0469)

NATIONAL INSTITUTE OF TECHNOLOGY

ROURKELA 769008, INDIA

Certificate of Approval

This is to certify that the thesis entitled **DESIGN OF ERGONOMIC KNIFE HANDLE** submitted by **Ms. Ayushi Khetan** has been carried out under my supervision in partial fulfilment of the requirements for the Degree of Bachelor of Technology in Industrial Design at National Institute of Technology, Rourkela, and this work has not been submitted elsewhere before for any other academic degree/diploma.

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Dr. Mohammed Rajik Khan

Assistant Professor

Department of Industrial Design

National Institute of Technology, Rourkela

Rourkela-769008

Date:

Acknowledgement

I have taken efforts in this project. However, it would not have been possible without the kind support and help of many individuals and the department. I would like to extend my sincere thanks to all of them.

I am highly indebted to Department of Industrial Design for providing necessary information and guidance regarding the project and also for their support in completing the project.

I would like to express my gratitude and special thanks to my project guide Dr. Mohammed Rajik Khan, Assistant Professor, Department of Industrial Design, NIT Rourkela, for all the cooperation and time. I would also like to thank my head of the department Prof. Bibhuti Bhusan Biswal for giving me such attention and time.

My especial thanks to Mr. Nagmani, all the technical staff and the office staff and people who have willingly helped me out with their abilities to understand various operations and machines.

Last but not the least we would like to thank my parents and National Institute of Technology Rourkela for giving us this wonderful opportunity.

Ayushi Khetan

Abstract

Knives! Although they are not the most expensive piece of equipment in a commercial kitchen, they are the most valuable. The aim of the present research is to design a customized knife handle based on different postures of hand while cutting in kitchen. A customized design is made using taking imprints of various hand postures on a soft clay cylindrical handle. Proposed design is compared with the existing handles and is assessed with the group of selected candidates during its usage and is statistically analysed with other existing handles. The effect of purchasing factors and the comfort rating is thoroughly analysed. The effect of shape and sizes of various knives are identified on different areas of the hand. Results are finally shown with the statistical analysed data.

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1. Introduction

A knife is a cutting tool with a cutting edge or blade, hand-held or otherwise, with or without a handle. Knives are used for a variety of purposes. It includes usage of knife as weapon, as sport's equipment such as sports knife, as utensils such as kitchen knife, bread knife, etc., as tools and as traditional and ritual implement. Thus knives are of great importance as it is used in a wide variety of work and most important as a cutting tool in all the houses. Most modern-day knives follow either a fixed-blade or a folding construction style, with blade patterns and styles as varied as their makers and countries of origin.

Knife is the common cutting tool used in all the families and it is very necessary that it serves its purpose and fits in the human hand with proper handle size and grip. It has been known that by long working hours or regular use one may find blisters, numbness, cramped muscles, slip, infections, etc. in hand. So, ergonomic design of knife handle is essential where researchers can work.

In this chapter the need to take up this work along with background is discussed. It also presents a review of available relevant literature. Objectives of the present work along with methodology adopted to accomplish the goals have been discussed here.

1.1 Background of the work

The design of any product must account for user safety, comfort, perception, and effective operation. Designing any product for a specific end user can be very challenging, especially if the device is in contact with the body. While using a knife many parts of human hand such as palm, fingers, elbow, and wrist are used and it determines the precision of cutting. Prolong use of knife causes several types of discomfort such as pain, sweat, dirt accumulation. The ergonomic factors while designing a knife can be summarised as, stretch of muscles and ligaments to their extreme position, for example a very wide grip by fingers and thumb. Speed of repetition, and its duration. Strength required or exerted. There are many similar instances. Psychology - a background of mental and physical tension, giving a 'white knuckle' grip instead of a relaxed one just adequate for the task. Susceptibility - of a group of people doing the same task, some will suffer strain or varying degree, and others will be quite unaffected. Those with previous injuries to the arm or neck are especially at risk, and so are people with hypermobile joints.

More than fifty criteria for handle design are grouped under 13 principal headings, Size , Shape , Surface, Security ,Stiffness , Siting , Surroundings , Signify function , Sensing features , Storage , Special other features , Skill needed , Validating design.

1.2 Problem definition

Knife being one of the common tools used by almost every person is supposed to have a design in such a way that it is convenient and comfortable to use and at the same time it serves it purpose in a rightful manner. This work makes an attempt to design and develop a kitchen knife with increased comfort on hand during its use. The design of knife handle is obtained by combining the features and attributes of different hand postures while cutting. The final design is done by taking the survey from users and redesigning is done based on comfort rating of various knives. The comfort of the hand leads to the concentration and effective cutting of vegetables.

The main objectives of this task can be determined as follows

- To design an ergonomic handle for kitchen knife.
- To perform subjective assessment on different shape of existing kitchen knife handles.

- Statistically analysing comfort and discomfort levels of various handle shape on various zone of hand.
- Redesigning the knife based on the survey results.

1.3 Review of literature

The study of knife handle design contains several research domains. Major issues related with this work include the size and shape of handle design for the vegetable cutting knives. The gripping is necessary in the handle design so as to work with the knife for long working hours.

In the previous research papers [1], they worked for the optimal handle shape that is required of generalized hand tools. The research included subjective analysis on a cylindrical handle and a designed handles that will fit the hand and will be easy to use.

The effect of handle size and shape in the measurement of grip force is also done in the precious research papers. It is analysed that how grip force required for different handle diameter differs [2]. It used a Jamar dynamometer and shear strain gauges installed in pockets near the base of the measuring arm using the previous methodology proposed by [3].

High grip forces are also considered to be a contributing factor in the development of hand-arm vibration syndrome (HAVS) as was researched by previous researchers [4].

Previous research also includes how the handle size and shape affect the stabbing performances of the knife. It was concluded by various tests that were performed on armed as well as unarmed subjects [5].

Other works include the shape and size of handle for chopper knives that are to be used in meat processing industries. The chopper knives are supposed to be able to withstand high impact energy as well as the design should also allow to lower the accumulation of the dust as the area will be dirty and processing will include long working hours.

The research of David J. Cochran and Michael W. Riley on The Effects of Handle Shape and Size on Exerted Forces [6] empirically evaluated the effects of handle shape and size on the hand's ability to resist or exert force in six directions. Thirty-six handles of four sizes and nine shapes were tested for maximum force exertion by male and female subjects. The results show that subjects were able to generate higher forces with different sizes and shapes of handles, depending upon the direction of force exertion. This suggests that handles that are associated with high forces on particular directional tests are probably suited for tasks that

incorporate that particular type of force or movement; they may not be appropriate for other tasks that do not incorporate such movement.

1.4 **Methodology**

The approach adopted to accomplish the present work is described below:

- Selecting and classifying various shapes of kitchen knife handles.
- Customizing a knife handle keeping in consideration different hand postures.
- Collecting point cloud data of selected knife handle in CAD environment.
- Capturing and converting the comfort profile shapes from the digitized surface data of various knife handles into a single surface profile of knife handle
- Subjective assessment of comfort ratings in the selected knife handle.
- Designing and development of a modified knife handle with increased comfort on human hand.
- Verifying the comfort level of proposed knife handle.

2. Design of a customized knife handle

This chapter includes all the steps that were used for the design of a customized knife handle. Its main focus was the use of different hand postures that are used while anyone uses a knife. The design was made using soft clay by making a cylindrical handle and then superimposing the various hand postures on it. After the clay took it shape it was scanned and then processed so as to make the CAD design. The reverse engineering of the clay was done so as to make the mould for the preparation of the prototyped design. The mould was made using the 3D printing machine. The final prototype was made using 'Plaster of Paris' and then doing the surfaces finish using a sand paper.

2.1 Determination of optimal surface of pre-handle

The first step was the design of an optimal pre handle using soft clay by making a cylinder of diameter of 35 mm. The next step includes the design of the handle on the cylinder based on the different comfortable working posture while cutting any vegetable in kitchen. The three main hand postures while cutting are as shown

Figure 1. Various holding techniques for vegetable cutting

The design of handle after the modelling is done is as shown below

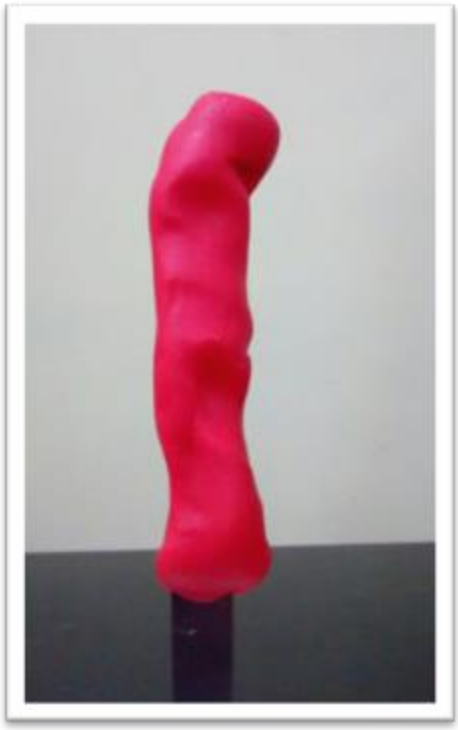

Figure 2. Customized handle design using soft clay

2.2 Mould generation using rapid tooling

For the preparation of the final design for the survey the modelled is first scanned using Faro Arm and then processing is done so as to design a mould for the designed knife. Various steps followed are as follows

Figure 3. Faro arm used for scanning

All of the following work is done in Catia V5R19 in the Digitized shape editor module.

Using the faro arm scanning of the knife handle is done and the point cloud data is obtained

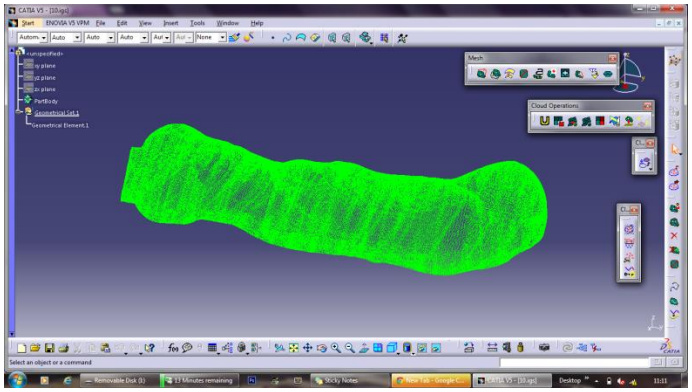

Figure 4. Point cloud data of customized handle

This point cloud data is then processed so as to form the meshed surface

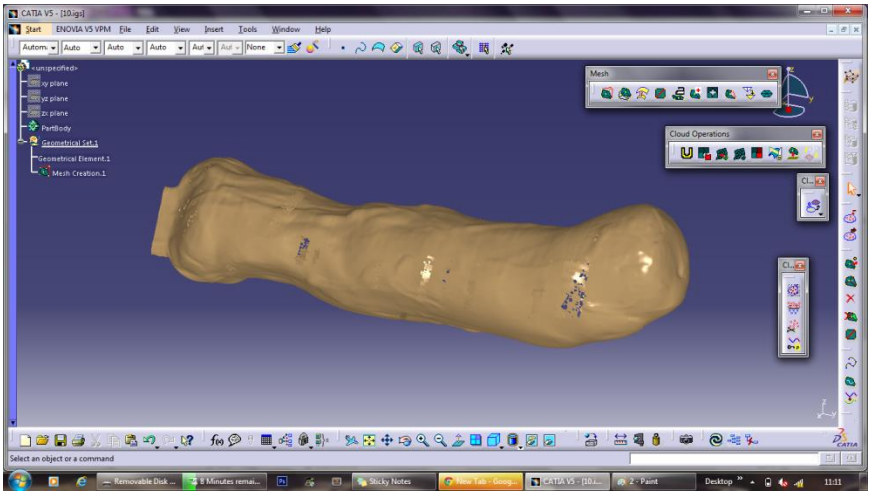

Figure 5. Meshed surface of knife handle

Since the meshed surface has a lot of non-manifold vertices and edges surface analysing is done so as to remove them. This analysed surface is filled using fill holes. Various discontinuities are filled using circular patches of various diameters.

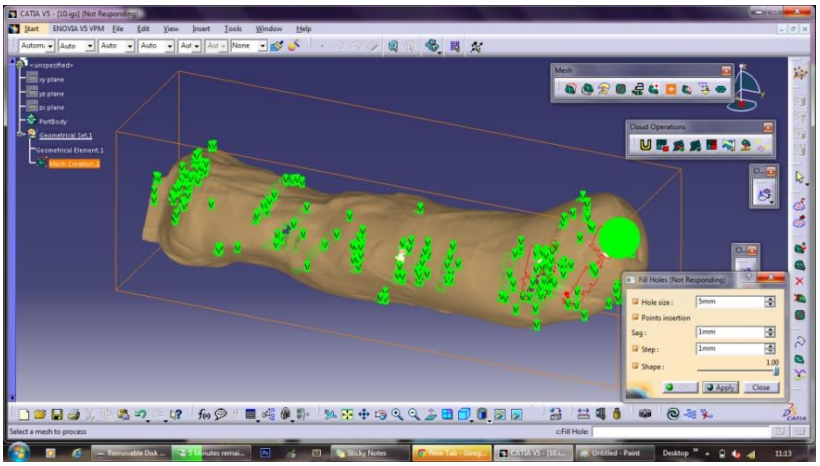

Figure 6. Filling holes for the knife

The final surface is then made smooth using mesh smoothing

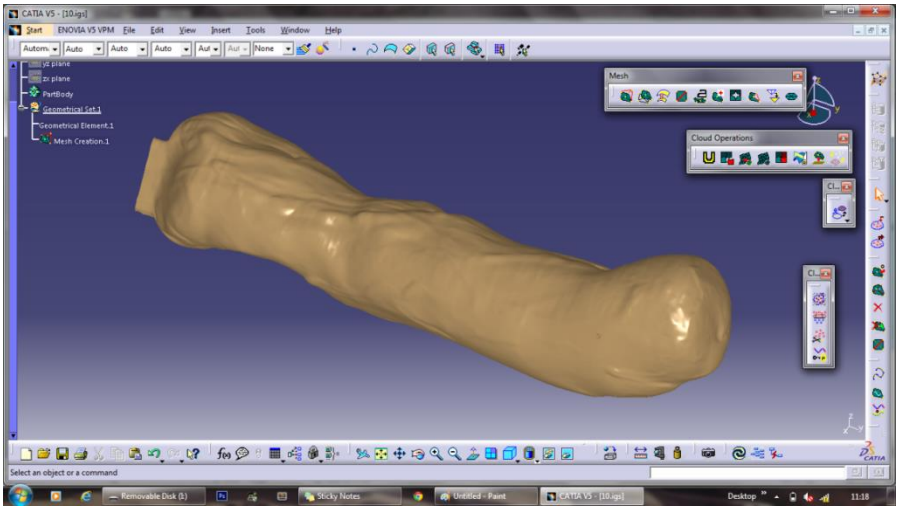

Figure 7. Smoothed meshed surface

After the final meshing is done and no more non manifold vertices are found during the mesh cleaner, automatic surface is generated in the 'quick surface reconstruction' module

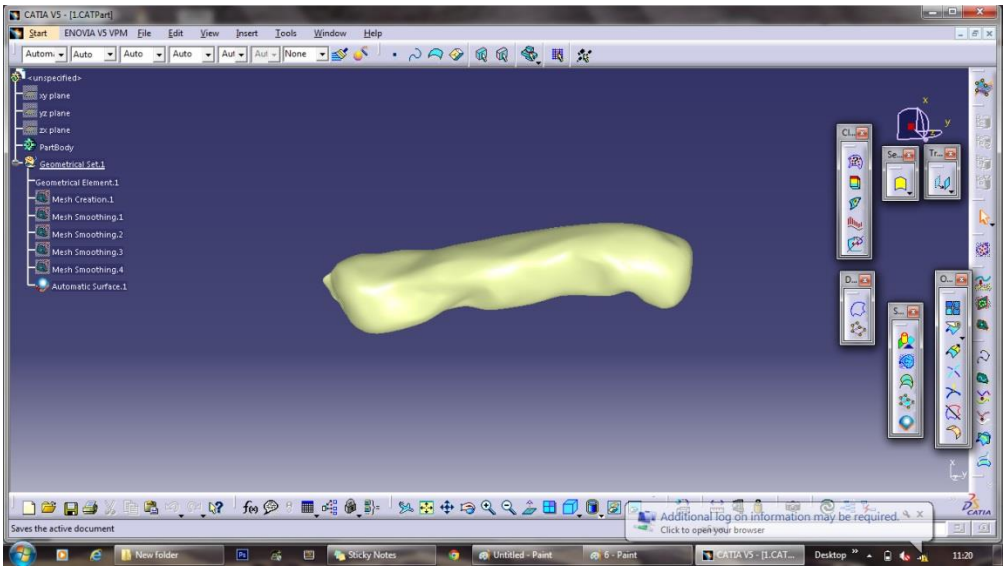

Figure 8. Surface generated for the knife handle

After the surface is generated reverse engineering is done so as to form the mould for the generation of prototype. Mould for the given surface is drawn by removing the surface from a block of rectangle and then splitting it. The main reason behind the split is to remove the prototype easily without destructing the mould.

The final mould design is saved in the stl file format and is imported in the 3D printer.

Figure 9. 3D printing machine used for mould creation

Figure 10. Mould generated

2.3 Prototype development

The prototype is formed using medical grade 'Plaster of Paris '. A liquid paste is made using 2:1 ratio of Plaster of Paris and water. Mould is aligned properly and tightly tied so that the orientation of the design does not get disturbed. The paste is then poured in the mould using a conical funnel. The mould is then left for 15-20 minutes so that the paste gets dried up. After the paste is completely dry, mould is opened slowly and the prototype is taken out carefully. Finishing of the prototype is done using a sand paper.

Figure 11. Customized knife handle

3. Handle Design: A Subjective Assessment

3.1 Consumer expectations in knife handle

While purchasing any product consumers have some expectations and their own needs for the product. In the case of a knife when any consumer goes to a shop the factors that he considers while purchasing the knife are its functionality, how easy is it to use, its task performance level, force transmission, friction between hand and handle, peak pressure, threshold pain, gripping, slippage, its weight, working posture comfortably, feeling i.e. emotional, looking professional, finishing, safety and styling.

The survey is done with 28 members; 15 boys and 13 females. Each survey included the weightage of each factor from 0 to 10 and then rating each knife on the scale of 1 to 5 based on the above factors.

The survey 1 is based on the weightage of each purchase factor. The questionnaire that was asked for the survey 1 is as follows.

Rate the given factors from 1 to 10 on the basis of how important the factors are while you purchase a knife: 10 denoting how important the criteria is and 0 the least important

Criteria	Rating
Functional	
Easy to use	
High task performance	
Good force transmission	
Good friction between hand and handle	
Do not Causes peak pressure	
Do not Causes pain	
Low hand grip force supply	
Do not slip	
Do not cause sweat	
Light in weight	
Comfortable working posture	
Has a nice feeling	
Looks professional	
Good finishing	
Safe to use	
Styling	

Table1. Weightage criteria for purchasing

In the survey 2 each knife is rated based on their various purchase factors. The questionnaire of it is as follows.

Rate the given characteristics of 6 different knives:

Criteria					
Functional					
Easy to use					
High task performance					
Good force transmission					
Good friction between hand and handle					
Do not Causes peak pressure					
Do not Causes pain					
Low hand grip force supply					
Do not slip					
Do not cause sweat					
Light in weight					
Comfortable working posture					
Has a nice feeling					
Looks professional					
Good finishing					
Safe to use					
styling					

Table2. Survey sheet for the purchase factor for different knives

The results of the survey1 i.e. the weightage showed the below results.

Factors	Weightage Average
Functional	8.962963
Easy to use	8.62963
High task performance	8.481481
Good force transmission	7.703704
Good friction between hand and handle	8.037037
Do not cause peak pressure	7.592593
Do not cause pain	8.592593
Low hand grip force supply	7.481481
Do not slip	8.222222
Do not cause sweat	7.296296
Light in weight	7.777778
Comfortable working posture	8.148148
Has a nice feeling	6.703704
Looks professional	6.185185
Good finishing	7.444444
Safe to use	9.296296
Styling	6.851852

Table 3. Average calculated for the weightage of purchase criteria

The results based on the survey number 2 for each knife based on the given purchase factors are

Factor	Knife 1	Knife 2	Knife 3	Knife 4	Knife 5	Knife 6
Functional	35.76533	34.496	32.85333	30.76267	24.64	35.91467
Easy to use	27.153	31.31934	33.618	28.37417	24.3515	33.68983
High task performance	31.376	30.316	28.69067	27.84267	23.67334	32.436
Good force transmission	27.98542	23.74342	24.62717	24.33258	16.85017	25.51092
Good friction between hand and handle	29.24258	27.77042	31.51775	29.3095	23.08625	30.38017
Do not cause peak pressure	25.48975	23.84525	25.48975	25.74275	19.1015	25.61625
Do not cause pain	29.77867	30.065	30.42292	26.77217	24.19517	32.92833
Low hand grip force supply	26.11767	26.80333	24.62167	24.497	23.99834	28.73567
Do not slip	26.03	28.633	26.6465	29.7975	21.098	32.4005
Do not cause sweat	22.113	23.9355	24.3	24.4215	23.2065	28.431
Light in weight	17.4825	29.526	27.51875	29.46125	34.38225	26.74175
Comfortable working posture	24.31417	26.62333	29.13625	26.96292	23.77084	32.80375
Has a nice feeling	20.9375	24.00833	25.46	21.6075	17.53167	23.45
Looks professional	23.999	22.145	19.467	16.1195	14.3685	21.9905
Good finishing	27.776	30.566	25.668	22.072	18.352	26.35
Safe to use	32.12792	34.373	30.73442	30.96667	27.63775	36.15358
Styling	25.91584	27.17167	24.3175	21.80584	17.125	27.51417
Total	454.6043	477.3406	468.0897	444.8482	382.3688	507.0471

Table 4. Survey result of purchase factor for 6 knives

3.2 Comfort assessment for knife handle

The various comfort factors while using a knife are the area fit, nice feeling, not causing inflamed skin, not causing peak pressure, not causing blisters, does not cause numbness and does not cause cramped muscles.

The comfort rating is taken from the users on various areas of the hand. The hand was divided into 5 areas based on the surface of the knife handle it is used for. The pictorial representation for the area of hand is

Figure 12. Areas in which the hand is divided for the survey

The questionnaire for the survey number 3 and 4 are based on the weightage and comfort rating for each factors.

The questionnaire is as follows.

Survey 3- Rate the given factors from 1 to 10 on the basis of how important the factors are while you purchase a knife: 10 denoting how important the criteria is and 0 the least important

Criteria	Weightage
Fits the area	
Provide a nice feeling	
Do not cause inflamed skin	
Do not cause peak pressure	
Do not cause blisters	
Do not cause numbness	
Do not cause cramped muscles	

Table 5. Survey sheet for the weightage of comfort rating

Survey 4- Rate how the knife feels at different regions of the hand

Criteria	Knife					
Fits the area	1					
	2					
	3					
	4					
	5					
	6					
Provide a nice feeling	1					
	2					
	3					
	4					
	5					
	6					
Do not cause inflamed skin	1					
	2					
	3					
	4					
	5					
	6					
Do not cause peak pressure	1					
	2					
	3					
	4					
	5					
	6					
Do not cause blisters	1					
	2					
	3					
	4					
	5					
	6					
Do not cause numbness	1					
	2					
	3					
	4					
	5					
	6					
Do not cause cramped muscles	1					
	2					
	3					
	4					
	5					
	6					

Table 6. Survey sheet for the ranking of comfort rating of different areas of hand

STRONGLY DISAGREE (1)

DISAGREE (2)

NEITHER AGREE NOR DISAGREE (3)

AGREE (4)

STRONGLY AGREE (5)

The weightage i.e. the importance comfort factors are taken from each user and the average of it is calculated.

Factors	Average
Fits the area	7.961538
Provide a nice feeling	7.653846
Do not cause inflamed skin	8.961538
Do not cause peak pressure	8.269231
Do not cause blisters	8.615385
Do not cause numbness	8.076923
Do not cause cramped muscles	8.576923

Table 7. Average of the weightage for the comfort rating

The overall result for the comfort rating of each knife area wise is calculated from the survey.

Area	Knife 1	Knife 2	Knife 3	Knife 4	Knife 5	Knife 6
Area 1	210.2003	167.0833	223.5849	173.8926	167.9679	254.7596
Area 2	198.7452	198.7837	194.9519	191.5385	180.891	217.4279
Area 3	157.1058	190.3445	156.0048	179.4615	185.4744	227.9119
Area 4	189.407	180.8445	206.7516	204.516	179.6138	212.4904
Area 5	185.7676	191.899	184.3237	178.9327	171.5385	199.8301
Total	941.2259	928.955	965.6169	928.3413	885.4856	1112.42

Table 8. Overall result area wise for each knife

4. Results and Discussions

The graph results for the survey 2 i.e. for the purchase factor of each knife is obtained in the IBM SPSS software and the following clustered graph result is obtained.

The graph shows the result based on different purchase factors. Different coloured bar denotes the different factors. On x- axis the score of each factor is mentioned whereas on Y-axis the different criteria are mentioned. The result in red bar denotes the rating of the customized knife handle.

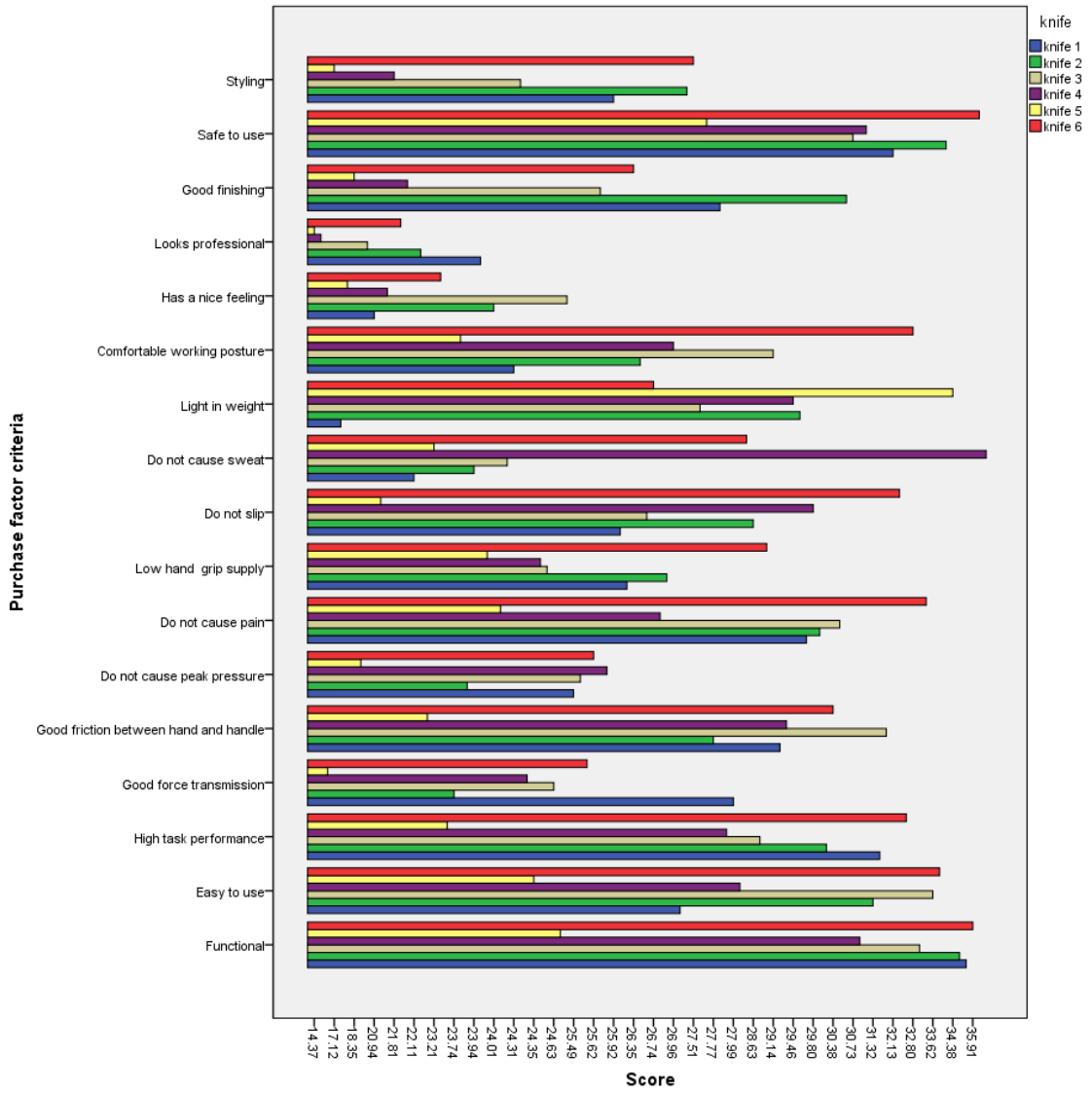

Figure 13. Graphical representation between purchase factor and score for each knife

Based on the weightage and rating of each knife, the total score of each knife is calculated in Microsoft excel and the results are plotted using SPSS. The total score each knife is plotted in the form of bar graph. The result is as shown below

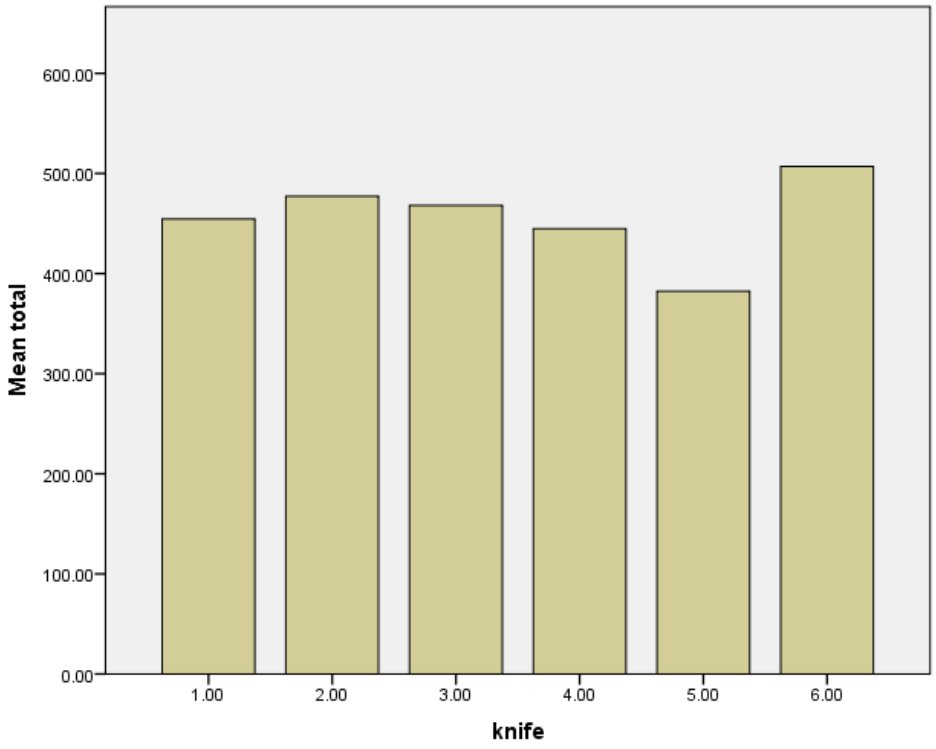

Figure 14. Overall purchase factor graph for 6 different knives

The results showed that the customized knife handle has the best properties for the purchase factors and can be considered as the best knife for purchasing.

For the survey 4 i.e. for the comfort rating of each knife area wise is obtained in the statistical software and it plotted as below..

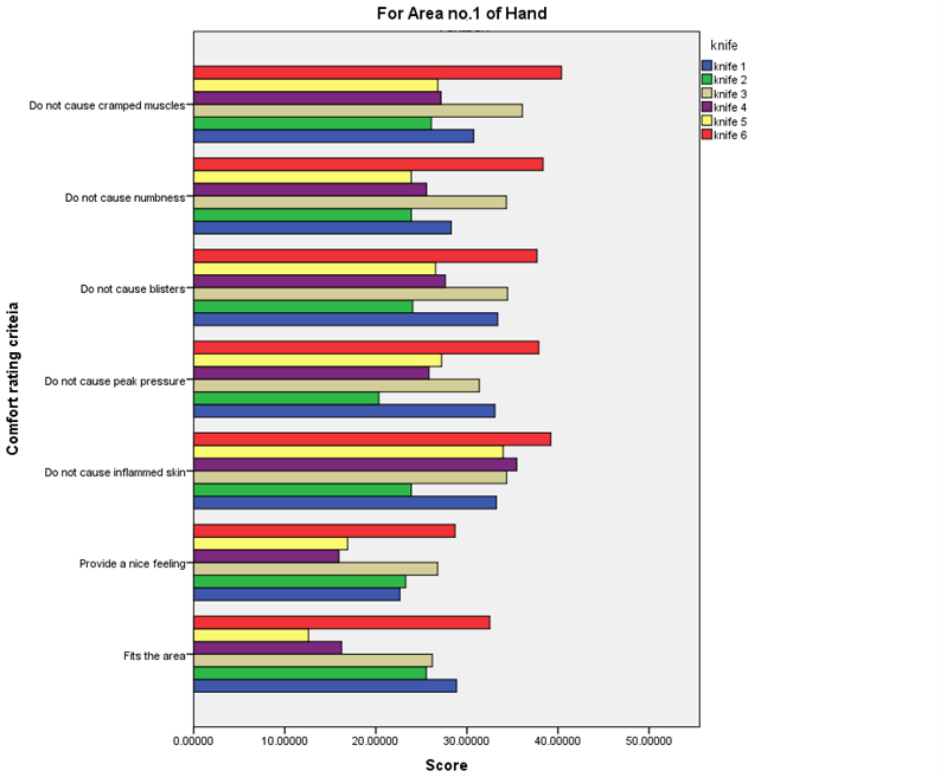

Figure 15. Comfort rating representation for area no.1 of hand

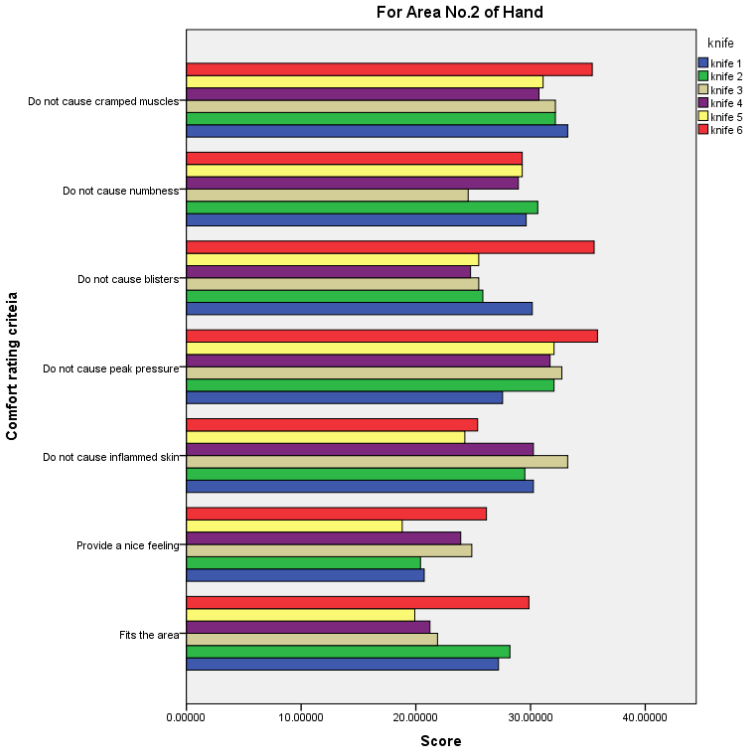

Figure 16. Comfort rating representation for area no.2 of hand

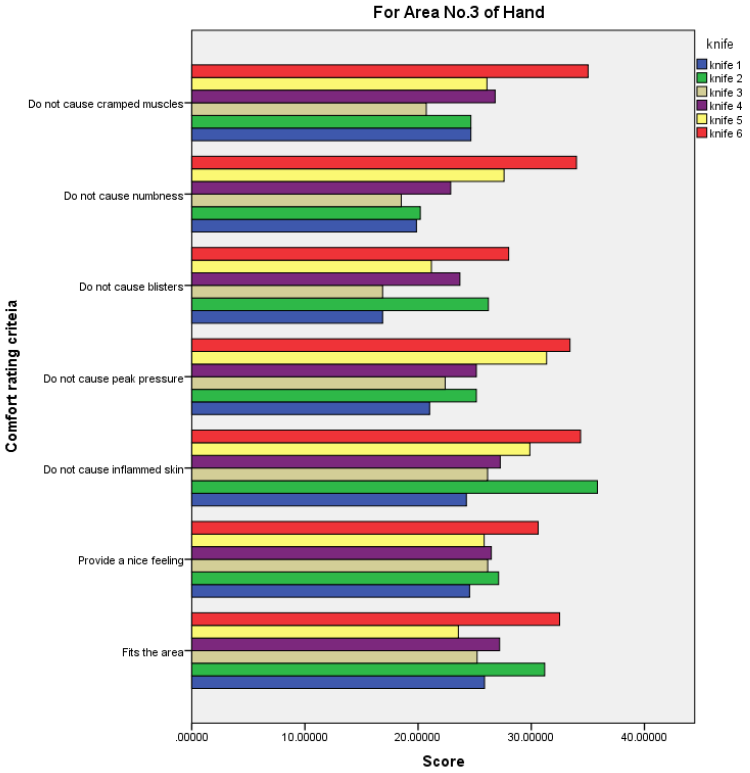

Figure 17. comfort rating representation for area no.3 of hand

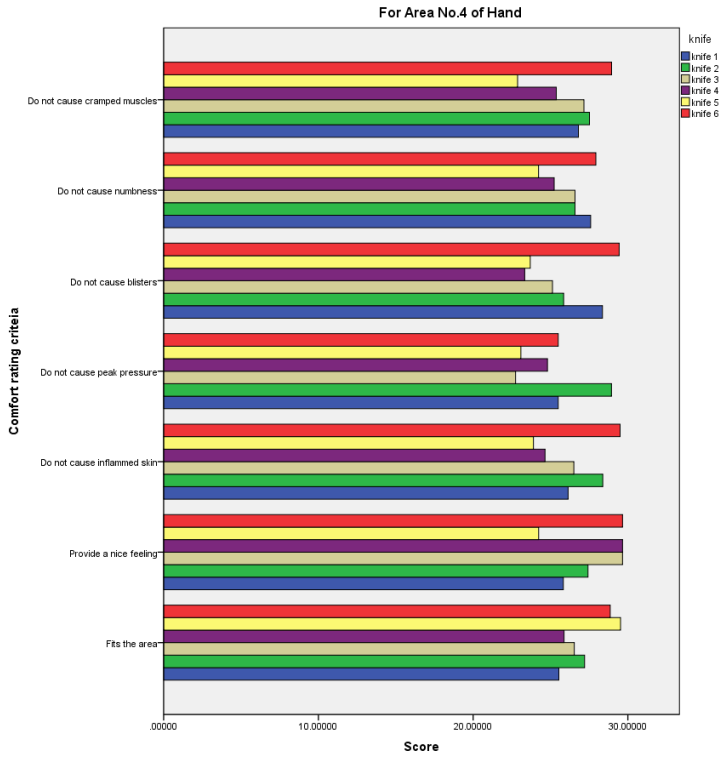

Figure 18. Comfort rating representation for area no. 4 of hand

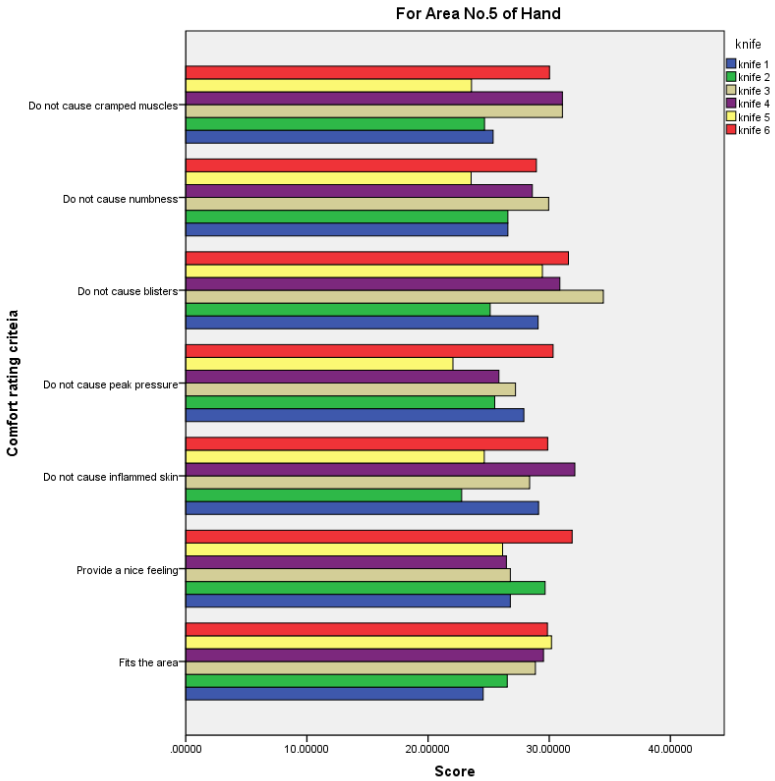

Figure 19. Comfort rating representation for area no 5 of hand

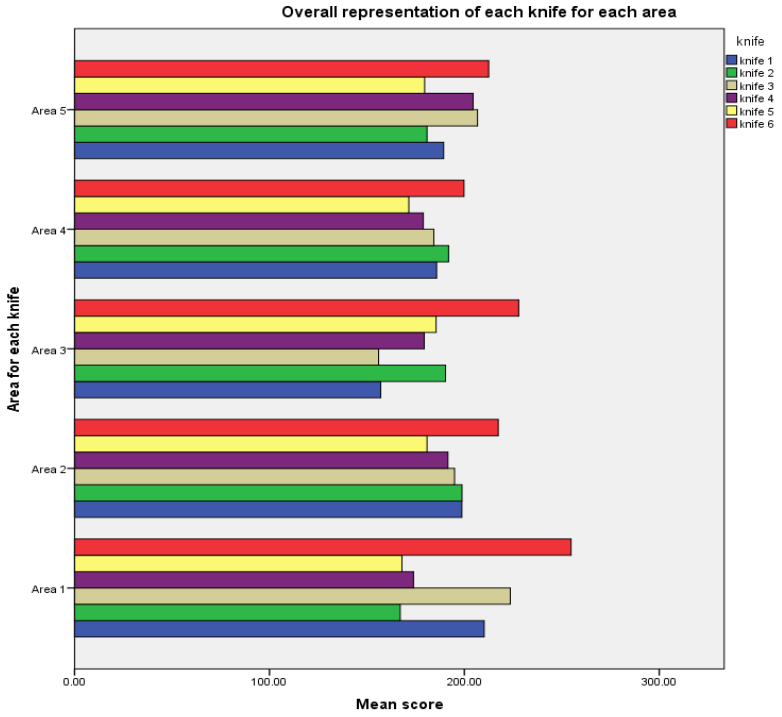

Figure 20. Overall comfort rating for each knife area wise

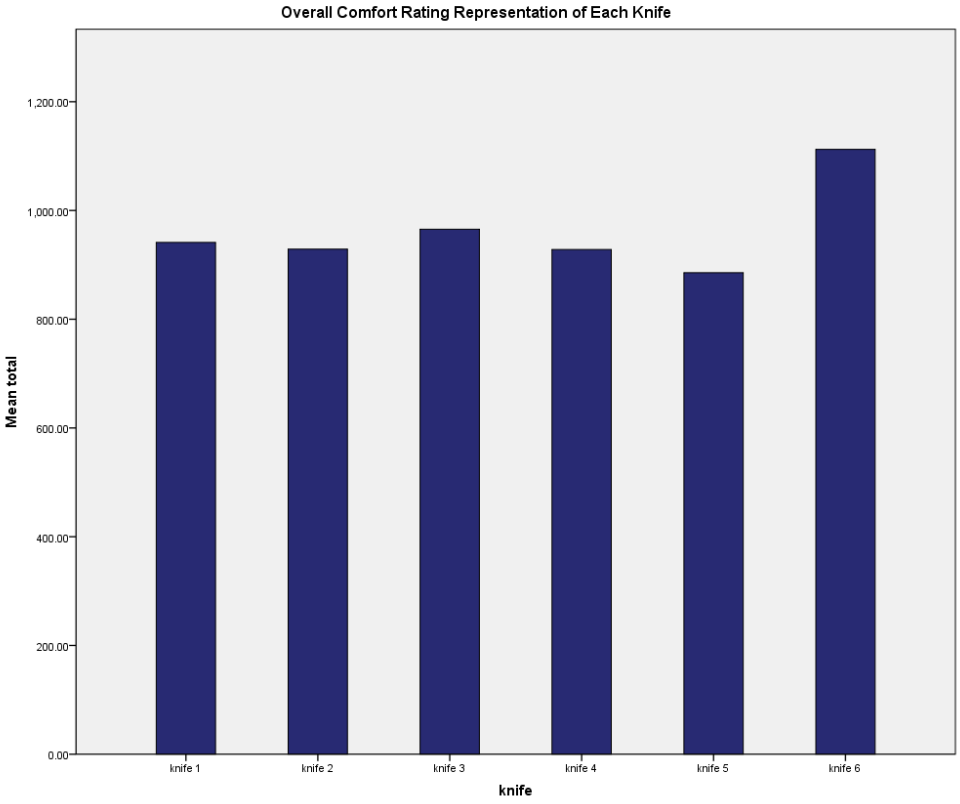

Figure 21. Overall comfort rating for each knife

5. Conclusion and scope of further work

According to the above results of purchase factor, the customized knife handle is best among various factors based on its score. The overall purchase factor score of each knife also shows that the customized handle design is the best proposed design. The results are concluded from analysing the survey data in statistical software.

The comfort rating weightage for each factor is also asked in the survey and is concluded that the knife do not case inflamed skin is the most important criteria for the comfort of a knife handle. The results of various knife handle based on purchase factor showed that the customized knife has the best properties in various areas of the hand and is thus has the best knife handle.

The scope of this work includes various pressures mapping so as to analyse at which point maximum pressure is felt so as to design in such a way that less force is exerted on the hand on that point. Further designing can include knife design for various hand dimensions so as to work comfortably.

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